ANTI-SUBMARINING SEAT-BELT ASSEMBLY

CROSS REFERENCE TO RELATED APPLICATIONS

This is a divisional application of the US-serial number 09/554,463 related to an international application number PCT/DE98/03270 (WO 99/24294, European Patent EP 1 037 773 B1, German Patent DE 197 49 780 C2) filed Nov. 10, 1998.

BACKGROUND OF THE INVENTION

1. Field of the Invention:

It is an object of the present invention to prevent a restrained passenger of a transport system (motor vehicle, ship, train or aeroplane) from submarining in the event of any accident (front-, side-, rear-end collision and/or rollover or pile up/mass collision) or during in-flight turbulence

2. Discussion of the Prior Art:

It is known in the prior art to provide for a passenger of a transport system an anti-submarining device in order to prevent severe/fatal injury in a rear-end collision.

In order to formulate in single terminology a generalized definition is presented for the proper term:

Definition:	**Proper Term:**
"Stiff first transport-system member"	Floor **6** of the transport system adjacent to a first seat-side SR (**Fig.** 1) or seat-cushion frame at the first seat-side or mid-tunnel (not drawn) of the motor vehicle adjacent to the first seat-side.
"Stiff second transport-system member"	Floor **6** of the transport system adjacent to a second seat-side SL or seat-cushion frame at the second seat-side or post section (not drawn) of the motor vehicle adjacent to the second seat-side or side rail of the motor vehicle adjacent to the second seat-side
"Seat frame"	Seat-cushion frame or seat-backrest frame

In order to prevent whiplash front seats of SAAB 9-5 cars are equipped with active head restraints (rests) that, each activated by the mass inertia force of the upper part of the body (torso) in rear-end collisions, move up and closer to head of the front-seated occupant. See shortcomings, undermentioned.

In collaboration with Autoliv Corp., the biggest car-supplier in the world, Volvo Corp. has developed WHIPS (Whiplash Injury Prevention System), installed in the front seats of Volvo S80s. Under load of mass inertia forces of a passenger's torso in a rear-end collision the hinge of the seat backrest yields and partially rotates backwards and downwards to facilitate the head rest to intercept the head and the seat backrest, filled with pads, to absorb forces. When a car crashes into the rear section of a S80 and both catch fire, the front-seated passengers and their seat backrests, rotated backwards and downwards, impede the evacuation of the back-seated passengers, who may be severely injured. The front-seated passengers must sit up in order to take further action. Taken as given, the rotated seat backrests cannot be returned to the home position precious time elapses to step out of the car. This raises the question of how the unscathed passengers and/or unscathed back-seated children, exposed to explosion, burn and/or toxic smoke, can evacuate themselves out of the car and/or how rescue workers can evacuate all the severely injured back-seated passengers.

Due to lack of space, in which the SAAB and Volvo protective devices should be installed, heads of rear-seated passengers are unprotected, hence, subjected to whiplash and severe/fatal injury resulting from submarining. For sure, both protective devices remain ineffective in a multi-crash when the front-seated passengers, being submarining underneath their respective lap belt portions, is crushed into death by the airbags, deployed in the front-end crash or falsely deployed in the rear-end crash.

Exemplified in DE 43 36 351 A1 (US serial no. 979,938), a pan, moveable along a pair of rails beneath the seat cushion, is activated in a rear-end collision and moved out therefrom to intercept a passenger when submarining and falling down therefrom. Ref. to EP 0 403 072 A2 (US serial no. 364,765) a pair of U-shaped ramps is built in a rear seat. Each ramp comprises two longitudinal members, both fastened to the vehicle floor, and a lateral member, which, arranged along the front portion of the rear seat, intercepts a submarining passenger in a rear-end collision.

Both anti-submarining devices can never prevent severe/fatal injuries linked to great belt force, deployed or falsely deployed airbags, different weights and/or different body proportions.

When a Ford Mondeo, swerving on a road outside the city Idstein, crashes twice into a barrier and finally into a bus, the face of an obese female driver, submarining, is fractured and crushed by the airbag into her skull. In the real-world multi-front-end collision at far higher speed and strong yaw-acceleration great rotatory- and longitudinal-acceleration dependant forces (**Figs.** 4, 5) enormously elongate the lap belt portion underneath which the belted passenger submarines in the direction „L_y" or „Z_E" (**Figs.** 4 and 7) due to the limitation of the belt pretensioner which can only retract the seat belt up to 30 cm. The accident report "U260901" is incorporated herein. All the anti-submarining devices, above-mentioned, can never prevent obese passengers from submarining when their car is involved in a real-world multi-front-end collision.

Any belted passenger, lying in a sleeping position ref. to DE 37 41 831 C2 (**Fig.** 7), submarines when being loaded by great mass inertia force „S_y" in the direction „Z_E" in the event of accident.

In view of foregoing shortcomings and deficiencies, there is a need to ensure the restraint of any passenger as well as the operation of the anti-submarining devices in any accident.

SUMMARY OF THE INVENTION

Accordingly, the principle object of the present invention is to provide for passengers of a transport system anti-submarining seat-belt assemblies which resolve the above-mentioned shortcomings and deficiencies, prevent submarining, absorb impact energy in the event of an accident or during in-flight turbulence and are suited for two-, three- and multi-point seat belts.

A second object of the present invention resides in one-click operation by means of a master release button, when depressed, to release the main and anti-submarining latch plates from the respective buckle assemblies. In emergency cases paramedics and fire-fighters can easily rescue the injured passengers.

A third object of the present invention resides in a cost-, space-saving integration of a multi-point seat belt, equipped with energy absorbers, the anti-submarining seat-belt assembly and

the seat into a safety seat, which can be converted into a baby-cot, child-seat or adult seat and vice-versa, illustrated in **Figs.** 1, 5.

INDUSTRIAL APPLICABILITY

It should be apparent that the invention provides substantially improved restraint including the following features:

a) The survival chance is enhanced by the restraint of

* both shoulders and the torso, when the passenger is thrown forward (**Table** 3) and/or subjected to the yaw Ö-acceleration-dependent torque $T_{ö}$, and
* both thighs and the lower part of the body, when the passenger submarines.

b) A number of sets of energy absorbers ref. to US serial no. 09/554,464 (WO 99/24292, PCT/DE98/03271, European Patent EP 1 037 771 B1, German Patent DE 197 58 498 C2 and CA pending patent 2,314,345) or German Patent DE 197 58 497 C2 can be attached to coupling fittings of anti-submarining seat belt assemblies (**Figs.** 3a, 3b, 3c). Hence, large impact energy can be gradually absorbed below the respective injury-related values. Several sets of energy absorbers can be attached to a length-adjustable belt of the anti-submarining seat belt assembly **8b, 8c** (**Fig.** 1). The inventor of the present application has submitted those patent documents and applications to CIPO as well as USPTO. The energy absorber consists of a number of clamping elements, having sites of predetermined fracture, and a retaining element, which, fastened to the seat backrest frame and/or seat frame, can serve as an integral part thereof.

c) Owing to the different positions of anti-submarining buckle assemblies, in plug-in connection with the respective anti-submarining latch plates, passengers of different body proportions, thighs and weight can adjust the length of the anti-submarining belt portions **1.3R, 1.3L** by themselves. Moreover, the adult seats, equipped therewith, can be modified for children and vice versa, thus increasing the rate of seat occupancy in a bus, train or an aeroplane, exemplified in **Fig.** 5. In another embodiment the length-adjustable belt of the anti-submarining seat belt assembly **8b, 8c** facilitates, for example, a female passenger to adapt the belt length to her long gown or to herself, when lying in sleeping position (**Figs.** 1, 7).

d) For safety reasons and easy access the anti-submarining latch plates **11, 25**, when not being used, are stored in a storage box **25.5** (**Fig.** 5). The belt-detachable anti-submarining latch plates **25** (**Fig.** 2) are attached to the lap belt portion when needed.

e) For the convenience of the passenger, when stepping out, or for a fast rescue of the passenger injured in an accident, the master release button **84** of the buckle assembly **9.1** is depressed to release all latch plates from the buckle assemblies.

BRIEF DESCRIPTION OF THE DRAWINGS

A number of embodiments, other advantages and features of the present invention will be described in the accompanying tables and drawings with reference to the xyz global coordinate system:

Table 1 shows test data such as left / right thigh-force, belt force and pitch-angle of driver and co-driver in 50% offset crash test of several European vehicles at crash speed of 55 km/h.

Table 2 shows yaw angle O of driver / co-driver in a 50% offset crash tests.

Table 3 shows test data of the safest child-restraint system Chico Shuttle® at the converted velocity of 55 km/h in comparison with the safest vehicle among them listed in **Table** 1.

Fig. 1 is a perspective view of a seat with upper buckle assemblies and anti-submarining buckle assemblies **7, 8, 8a to 8d**, attached to the seat backrest and seat cushion, as well as of a restraint system consisting of a multi-point seat belt **1**, latch plate **11** along the lap belt, shoulder latch plate **2** of belt end, in the direction of arrow „Z" in plug-in connection with an upper buckle assembly **4**, and a seat belt in X-shape, formed by crossing both shoulder belt portions **1.1, 1.2**.

Fig. 2 is a schematic view of a detachable anti-submarining latch plate **25**.

Fig. 3a is a schematic, perspective view of a 1st embodiment of a buckle assembly **4a**, equipped with a release cable **4.2**.

Fig. 3b is a schematic, perspective view of a 2nd embodiment of a buckle assembly **4b**, equipped with an electrical release-motor **4.2b**.

Fig. 3c is a schematic, perspective view of a 3rd embodiment of a buckle assembly **4c**, equipped with a release cable **4.3**.

Fig. 4 is a perspective view of a anti-submarining latch plate **11** of a lap belt portion **1.3** in plug-in connection with the anti-submarining buckle assembly **8**.

Fig. 5 is a front view of the seat **3a to 3d**, in which the restraint systems **1a to 1d,** anti-submarining seat-belt assemblies and storage boxes **25.5** are integrated, for passengers of different weights, different circumference of thighs and different body proportions (sizes), where anti-submarining buckle assemblies are in plug-in connection with the anti-submarining latch plates **11, 25**.

Fig. 6 illustrates two curves of strain/elongation rate dependent from force ref. to PCT/US99/13362 (US 09/098,294).

Fig. 7 is a top view of a ∠- shaped seat belt ref. to DE 37 41 831 A1, where a belted passenger, in sleeping position, under load of great mass inertia force „S_y" in the direction „Z_E" submarines.

DESCRIPTION OF THE PREFERRED EMBODIMENTS OF THE INVENTION

The advantages of the preferred embodiments in the Chap. "INDUSTRIAL APPLICABILITY" are outlined hereinafter with regard to the functions and features thereof.

Just at a crash speed of 55 km/h the belt force of a driver of the premium car AUDI A8 is measured 9,130 N (**Table** 1) equivalent to 2,015 Pound by which the seat belt is elongated (strained) about 19 % (**Fig.** 6). The elongation ranges from 47.5 to 57 cm when the seat belt is 2.5 to 3 m long. In case the belt pretensioner remains inoperative and, in particular, the total mass inertia force „S_y" of the lower part of the body of the passenger is far larger than that of the upper part of his body slips (submarines) underneath the lap belt portion in a real-world accident. The method of the present invention capitalizes on the premise that a lap belt portion, restraining a lower part of the body of the belted passenger, is subdivided into two anti-submarining belt portions **1.3R, 1.3L** which properly restrain as well as hold his thighs when plug-in connecting at least one anti-submarining latch plate **11, 25** to the respective one of anti-submarining buckle assemblies **7, 8, 8a to 8d**, all of which are equipped with energy absorbers, shown in **Figs.** 1, 4 and 5. As a result, the anti-submarining seat-belt assembly in association with energy absorbers

- substantially lowers large belt force, for example, of 15,190 N at only 55 km/h (**Table** 1), in a real-world accident or during in-flight turbulence,
- prevents large elongation of the seat belt webbing, severe/fatal injury and the passenger of a Mercedes Car, lying in the sleeping position (**Fig.** 7), from submarining and

– ensures the operation of the active head restraint of SAAB 9-5 and Volvo's WHIPS.

In an embodiment the release button **84f, 84e** of free-moving anti-submarining buckle assembly **8b, 8c (Fig.** 1), whose housing is free-moving on the seat cushion and whose length-adjustable belt is fastened to the seat frame, can be controlled neither by a release cable **4.2** nor by an electrical release-motor **4.2b**. Hence, the release button **84e, 84f** can only be activated by an electrical signal emitted from the master release button **84,** when depressed, to remove the protection from submarining.

Because the reel (spool) of the conventional belt retractor can accommodate only a limited length of belt, it is possible that the length of the seat belt for the sleeping position is insufficient. The length-adjustable belt compensates for the length of seat belt **1** and accommodates the passenger, particularly when being obese, in all positions between the sleeping and normal position.

An anti-submarining buckle assembly **8d**, provided with a release button **84d**, is attached to the front portion of the seat cushion. This feature facilitates the obese passenger or a lady in a gown to restrain the thighs by plug-in connecting the anti-submarining latch plate **11** thereto.

Due to the plug-in connection of the anti-submarining latch plates **11, 25** with the anti-submarining buckle assemblies a lady in a long gown as well as a child are well protected from submarining. The anti-submarining belt portions, restraining a child's or baby's thighs with small circumference, are secured to the seat cushion by the latch plate **11**, plug-in connected to one of the anti-submarining buckle assemblies **8, 8a to 8d**, and the detachable anti-submarining latch plates **25**, plug-in connected to at least one pair of anti-submarining buckle assemblies 7 **(Figs.** 1, 5). For safety reasons and easy access the anti-submarining latch plates, when not being used, are stored and secured in a storage box **25.5** of the seat **(Fig.** 5).

In the 1st, 2nd and 3rd embodiment **(Figs.** 3a to 3c) the buckle assembly **4a, 4b, 4c** is form- and/or force-locking connected to the seat-backrest frame. For the convenience of the passenger when egressing from the vehicle and in cases of emergency the following embodiments of detachment are proposed:

To disconnect the latch plates **2, 11** and/or **25** from the upper buckle assemblies **4, 18, 18a, 18b, 18.1 to 18.3, 19, 19a, 19b, 19.1 to 19.3 (Figs.** 1 and 5) of the seat arrangement, particularly in the case of children, as well as from the anti-submarining buckle assemblies 7, **8, 8a to 8d (Figs.** 1, 4), the master release button **84**, when depressed, activates the release

cables **4.2** and/or electrical release-motors **4.2b**, which pull the release button **84a** and/or **84b** of all the buckle assemblies (**Figs.** 3a, 3b, 3c).

By law passengers travelling in a motor vehicle or experiencing flight-turbulence must remain belted. The need for a belted mother to turn around becomes apparent, when she must attend to her children sitting on the rear seat. The separately operated release buttons **84o, 84d, 84e, 84f**, when depressed, detach only the anti-submarining latch plates **11, 25** of the lap belt portions from the assemblies **7, 8, 8a to 8d** (**Figs.** 1, 4 and 5) to free the mother and/or children from the anti-submarining protection while the mother and/or children remain belted. The anti-submarining buckle assemblies **7, 8, 8a**, whose housings are located in the seat cushion **3.1, 3.1a to 3.1d**, have the common release button **84o** on the seat.

Although the present invention has been described and illustrated in detail, it is clearly understood that the terminology used is intended to describe rather than limit. Many more objects, embodiments, features and variations of the present invention are possible in light of the above-mentioned teachings. Therefore, within the spirit and scope of the appended claims, the present invention may be practised otherwise than as specifically described and illustrated.